We claim:

1. An apparatus for the production of synthesis gas including:

a reaction vessel;

a first heat exchanger, located within one end of said reaction vessel, to heat a preheated oxygen containing stream by indirect heat exchange with an oxygen depleted stream;

a second heat exchanger, located within the other end of said reaction vessel, to heat a reactant stream comprising at least one hydrocarbon and steam by indirect heat exchange with a synthesis gas product stream;

a plurality of oxygen transport membranes located in a reaction section of the reaction vessel to separate oxygen from the oxygen containing stream, thereby to produce permeated oxygen at anode sides of the oxygen transport membrane tubes, the oxygen transport membranes having cathode sides in communication with the first heat exchanger to receive the oxygen containing stream;

the reaction section in communication with the second heat exchanger so that the reactant stream is introduced to the anode side of oxygen transport membranes in said reaction section;

a catalyst bed located within the reaction section to promote the reaction of the permeated oxygen in a combination partial oxidation-reforming-water gas shift reaction to produce the synthesis gas product stream;

first entrant and discharge passages in communication with the first heat exchanger and second

entrant and discharge passages in communication with the second heat exchanger to allow for passage of the oxygen containing and oxygen depleted streams and for passage of the reactant and synthesis gas product streams, respectively, to and from the reactor vessel; and

the first heat exchanger, the second heat exchanger, and the oxygen transport membrane tubes each supported within the reactor vessel independently of one another so that each can independently expand or contract.

2. The apparatus of claim 1, wherein said reactant section has baffle plates configured to produce a flow of the reactant gas through the reactant section and therefore the catalyst bed of one of: axial flow, cross-flow, combined axial and transverse flow; spiral flow; radially-segmented cross-flow; and transverse-segmented cross-flow.

3. The apparatus of claim 1, wherein said oxygen transport membranes are tubular and said reactant section has perforated shroud tubes surrounding said oxygen transport membrane tubes.

4. The apparatus of claim 1, wherein the oxygen transport membranes are formed from oxygen transport membrane tubes; and an inert buffer gas zone is located between the reaction section and seal locations at the open ends of the oxygen transport membrane tubes to allow introduction of a non-reactive gas therein at a pressure greater than that of the

reactant zone to prevent leakage of reactant gas from the reactant stream into the oxygen containing stream.

5. The apparatus of claim 1, wherein each of the first and second heat exchangers has a heat exchanger tubesheet connected to the reactor vessel and a plurality of tubes connected to said tubesheet for internal passage of said synthesis gas product stream and said oxygen containing stream, respectively.

6. The apparatus of claim 5, wherein said oxygen transport membranes are of tubular configuration having closed and open ends and are supported at their said open ends from a support tubesheet located between the heat exchanger tubesheets.

7. The apparatus of claim 5, wherein said tubes divide said first and second heat exchangers into oxygen containing gas feed and oxygen depleted gas and feed gas and product gas sides, on opposite sides of said tubes, respectively and said second heat exchanger is configured such that higher mass velocities exist on said feed gas side than on said product gas side.

8. The apparatus of claim 1, wherein said second heat exchanger has first and second stages with a catalytic pre-reforming section located between said stages containing a pre-reforming catalyst to pre-reform hydrocarbons with more than one carbon

molecules to in turn form hydrogen and carbon monoxide therefrom.

9. The apparatus of claim 1, wherein said reaction section has a catalyst-free section at a location at which said reactant stream enters said reaction section to promote oxidation reactions over reforming reactions, thereby to promote rapid heating of reactant gases in said reactant stream and the oxygen transport ceramic membranes.

10. The apparatus of claim 1, wherein said catalyst bed has an oxygen transport membrane-free section to define a catalytic equilibrating section.

11. The apparatus of claim 1, wherein each of the oxygen transport ceramic membranes is of tubular configuration and of composite construction and has a porous support layer located on the anode side and an adjacent dense membrane film located on the cathode side thereof.

12. The apparatus of claim 11, wherein a reforming catalyst of said catalyst bed is located in an outer portion of said porous support layer.

13. The apparatus of claim 1, wherein the reaction vessel has an outer jacket to preheat the oxygen containing stream and a passageway communicating between the outer jacket and the first heat exchanger for flow of the oxygen containing stream thereto after having been preheated.

14. A process for the production of synthesis gas including:

compressing an oxygen containing gas to a pressure in a range of about 1.5 bar and about 4 bar;

heating said oxygen containing stream to an interim temperature in a range of between about 300°C and about 600°C;

preheating a reactant stream comprising at least one hydrocarbon, steam and a recycle gas, selected from the group comprising: hydrogen, carbon monoxide, and carbon dioxide, to a temperature greater than 200°C;

introducing said oxygen containing stream after having been heated into a first heat exchanger, located within a reaction vessel, to heat said oxygen containing stream by indirect heat exchange with an oxygen depleted stream;

introducing said reactant stream into a second heat exchanger, located within said reaction vessel, to heat said reactant stream to a temperature in a range of between about 500°C and about 750°C by indirect heat exchange with a synthesis gas product stream;

introducing said oxygen containing stream into a cathode side of a plurality of oxygen transport membranes located in a reaction section of the reaction vessel to separate oxygen from the oxygen containing stream, thereby to produce permeated oxygen at an anode side of the oxygen transport membranes;

introducing said reactant stream into a catalyst bed located at the anode side of said oxygen transport membranes and within the reaction section to

promote the reaction of the permeated oxygen in a combination partial oxidation-reforming-water gas shift reaction to produce the synthesis gas product stream;

withdrawing the synthesis gas product stream from the reaction vessel after having been cooled through the indirect heat exchange with the reactant stream; and

withdrawing oxygen depleted gas from said reaction vessel after having been cooled through the indirect heat exchange with the oxygen containing stream.

15. The process of claim 14, wherein reactant gases of the reactant stream traverse the reaction section and therefore the catalyst bed in one of: axial flow, combined axial and transverse flow; spiral flow; radially-segmented cross-flow; and transverse-segmented cross-flow.

16. The process of claim 14, wherein at least one of the composition of the reactant gases, an oxygen permeate rate of the oxygen permeating through the oxygen transport membrane tubes, and the activity of catalyst activity of catalyst located within the reaction section to promote reaction of the reactant stream and the permeated oxygen, is adjusted to balance locally the heat of the endothermic reforming reactions with the heats of exothermic oxidation and water gas shift reactions to the extent required for maintaining said oxygen transport membrane tube within an operating temperature range between 800 and 1100°C.

17. The process of claim 14, wherein a buffer gas zone is located between the first heat exchanger and the reaction zone and a non-reactive gas is introduced into the buffer gas zone at a pressure higher than that of said reaction zone to prevent leakage of reactant gas from the reactant gas stream into an oxygen containing stream.

18. The process of claim 14, wherein the discharge temperature of the product synthesis gas stream from said product second heat exchanger is maintained above 700°C to inhibit metal dusting therein and the product synthesis gas stream is further cooled outside of the reaction vessel in an external heat exchanger to below about 400°C against boiling water to inhibit metal dusting in said external heat exchanger.

19. The process of claim 14, wherein liquid water is injected into the product synthesis gas stream after exiting said reaction section to partially cool said product synthesis gas stream by quenching, thereby to inhibit metal dusting in the said second heat exchanger.

20. The process of claim 14, wherein the oxygen containing gas stream and the reactant gas stream have a temperature difference of greater than about 200°C where they enter reaction section.

21. The process of claim 14, wherein said reactant stream, within the second heat exchanger, is

initially heated to a temperature of about 500°C, then flows through a catalytic pre-reforming section thereof in which hydrocarbons having more than one carbon molecule are reformed into hydrogen and carbon monoxide to inhibit the formation of free carbon at higher temperatures and, is then thereafter heated to a temperature of above about above 700°C.

22. The process of claim 14, wherein said reactant gas is subjected to a partial oxidation reaction with oxygen permeate prior to entering said catalyst bed.

23. The process of claim 14, wherein said reactant gas after said reaction section undergoes reforming reactions in the absence of oxygen permeate within an equilibrating section.

24. The process of claim 14, wherein said process is started by introducing a start-up air flow to the reactor and injecting fuel into the start-up air flow leaving the reaction section to react with oxygen in the start-up air stream and continually injecting said fuel until the oxygen transport membranes reach operating temperature, at which time the reactant stream is introduced into the second heat exchanger.